# NEW CHAETETIFORM TREPOSTOME BRYOZOA FROM THE UPPER MISSISSIPPIAN OF THE WESTERN UNITED STATES

*by* JUNE R. P. ROSS

ABSTRACT. Two new bryozoan (ectoproct) genera are part of the fauna of the Late Mississippian carbonate facies in Utah, Idaho, Wyoming, and Montana. *Helenopora* gen. nov. is widespread and abundant whereas *Astralochoma* gen. nov. is more restricted and sparse. Gross external features of the bryozoan colonies (size, colony form, and shape of zooecial tubules) resemble chaetetiform colonies. Internal characteristics of the two new genera show them to be bryozoans with distinctive budding patterns. Because of the distinctive features of these two genera, the new families Helenoporidae and Astralochomidae are erected to accommodate them.

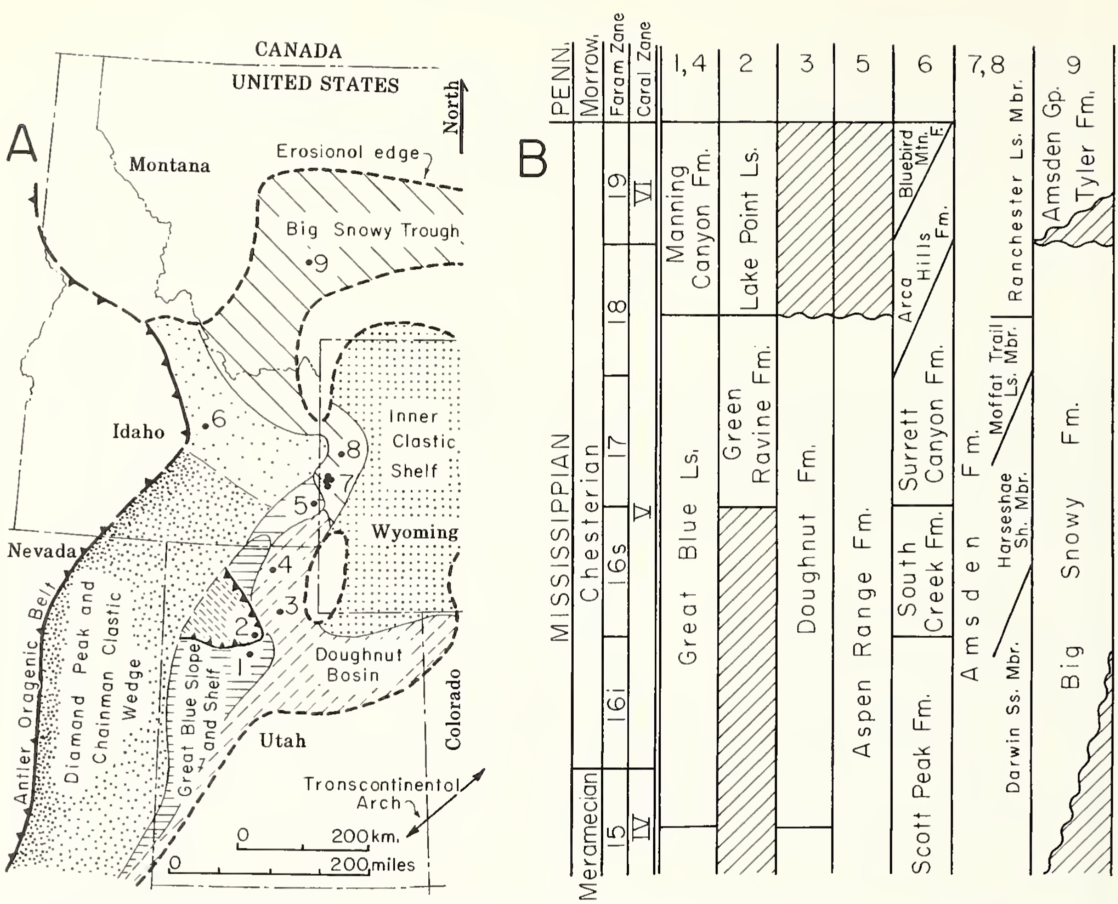
CHAETETIFORM trepostomatous bryozoans (ectoprocts) with subspheroidal or hemispheroidal colonies are found in Late Mississipian (Chesterian) faunas of the carbonate shelf facies that extended along the edge of the craton from Utah to Idaho, Wyoming, and Montana (text-fig. 1A). One genus, *Helenopora* gen. nov., was generally common and widespread in these shelf faunas whereas the other genus, *Astralochoma* gen. nov., appears to be much less common and has been found thus far only in Utah and Wyoming. The bryozoan colonies appear to have been located on shallow, shoreward edges of carbonate buildups, particularly where currents moved sand and other detritus. Features of sedimentation suggest this western outer shelf and trough region probably had good circulation of marine waters. Southern Utah and south-eastern Nevada, the area where the bryozoans lived, was most likely a cul-de-sac between the Antler orogenic belt and the transcontinental arch, at least for part of Chesterian time.

At localities in Utah and Wyoming, *Helenopora* is associated with corals and brachiopods. It predominates in what has been called the *Caninia* (*Siphonophyllia*?) Zone of the western interior of the United States. The *Caninia* Zone in the western United States (Sando *et al.* 1975) is identified as Western Interior North American Coral Zone V in the biostratigraphic sequence of Sando and Bamber (1979, 1984, 1985). Based on Foraminifera, this zone is correlated (text-fig. 1B) with the middle and upper parts of the Chesterian Series of the midcontinent region of the United States and with the latest Visean ($V_{3_{c_3}}$) and possibly early Namurian ($E_1$ and $E_2$) of Europe (Sando 1975; Sando and Bamber 1984, 1985).

The extraordinary external similarity of *Helenopora* and *Astralochoma* in colony form, size, and tubular structure of the zooecia to *Chaetetes* has resulted in the bryozoan colonies being mistaken for *Chaetetes*, particularly in the field. The late Helen Duncan, US Geological Survey, recognized the homeomorphy and segregated for study some of chaetetiform bryozoans. The specimens described in this report are part of that material. Duncan (in Tooker and Roberts 1970) identified the occurrence of two genera, here named *Helenopora* and *Astralochoma* (Chaetetiform bryozoan n. gen. A and Chaetetiform bryozoan n. gen. B, respectively, in Duncan's terminology; Tooker and Roberts 1970, table 1). The two genera are both present, but in different beds, in the Green Ravine Formation, Upper Mississippian, in the northern Oquirrh Mountains, Utah (region 2; text-fig. 1A).

Sando (1975) discussed and illustrated the two chaetetiform trepostomes, still calling them Chaetetiform bryozoan genus A and Chaetetiform bryozoan genus B, from the Amsden Formation, Salt River Range, Wyoming (region 7; text-fig. 1A). In that 1975 report, Sando described *C. wyomingensis* Sando, the first *Chaetetes* from the Mississippian of North America. This species of *Chaetetes*, from




TEXT-FIG. 1. A, distribution of localities in regions 1 to 9. Shading on the map delineates areas of similar depositional environments: region 1 is situated on the Great Blue carbonate shelf and slope; region 2 lies on a thrust sheet in the Green Ravine Formation; regions 3 and 4 are situated in the clastic and carbonate margin and basin that lie between the inner clastic shelf and the carbonate shelf and slope; region 5 lies on the Aspen Range carbonate shelf edge; region 6 is on the Surrett Canyon outer carbonate shelf; and regions 7, 8, and 9 lie on the shallow water, carbonate, and fine-grained clastic cratonic shelf-margin and intracratonic basin. B, stratigraphic sections for regions 1 to 9 and correlation of the geological formations. Regions 1 to 9 are listed at the top of the figure. The diagonal shading indicates missing stratigraphic intervals which, except for region 2, represent non-depositional or erosional hiatuses. In region 2, the Green Ravine Formation is the lowest unit exposed on a thrust sheet. This text-figure was compiled from data included in: Lageson *et al.* (1979): Sando (1976); Sando and Bamber (1979, 1984, 1985); Sando *et al.* (1975); Sando *et al.* (1969); Sando *et al.* (1981); Skipp *et al.* (1979); Smith and Gilmour (1979); Tooker and Roberts (1963, 1970); and Welsh and Bissell (1979).

## EXPLANATION OF PLATE 46

Figs. 1–5. *Helenopora duncanae* gen. et sp. nov. Upper Mississippian. 1, external view of hemispheroidal colony, USNM 419783, × 1, Chainman Shale, Granite Mountain, Confusion Range, Utah (USGS 20547-PC). 2, weathered surface of colony shows longitudinal section, USNM 419784, × ½, Doughnut Formation, near Mount Raymond, Wasatch Mountains, Utah (USGS 14496-PC). 3–5, tangential sections close to colony surface show distal structures within some zooecia, USNM 419785, × 50, Aspen Range Formation, Caribou County, Idaho (USGS 101-A).

PLATE 46


ROSS, *Helenopora*

the Moffat Trail Limestone fauna, is present at the same locality as the homeomorph chaetetiform bryozoan genus B (= *Astralochoma*).

Thin sections of the bryozoan colonies rapidly dispel any consideration that these homeomorphs belong to the genus *Chaetetes*. As Sando (1975) noted, the laminate thin walls, the polymorphism of the zooecia (including mesozooecia), the presence of styles, and the lack of pseudosepta do not permit assignment to the chaetetids. Although the two new families Helenoporidae and Astralochomidae are distinctly trepostomes and are not assignable to some other bryozoan order, they differ from established trepostome suborders and families in the combination of a number of diagnostic characters, such as parallel colony growth form, zooecial wall microstructure and other features, and zooecial budding pattern, that are discussed in the family diagnoses. The Helenoporidae includes certain features that characterize both the suborders Esthonioporoidea and Halloporoidea (Astrova 1978). For example, the Esthonioporoidea have the primitive character of parallel budding of zooecia from the basal epitheca, thin granular-laminate zooecial wall microstructure, and acanthoforms, but lack mesozooecia and exilazooecia. The Halloporoidea do not display the parallel budding of the zooecia from the basal epitheca, but do have mesozooecia and acanthoforms. The Halloporoidea have a more clearly defined laminate microstructure of the zooecial walls which is lacking in both the Helenoporidae and Astralochomidae.

The apparent restricted distribution of these two new trepostome families to a part of the western North American shelf margin and to a relatively thin zone in the upper Mississippian suggests they represent endemic genera with short stratigraphic ranges. On the other hand, because they superficially closely resemble chaetetids, it is possible they are geographically much more widespread, but have been misidentified as *Chaetetes* in hand specimens.

*Repository of material*. National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM) and United States Geological Survey, Paleontological Collections, Smithsonian Institution, Washington, DC (USGS).

## SYSTEMATIC PALAEONTOLOGY

Phylum BRYOZOA
Class STENOLAEMATA
Order TREPOSTOMATA
Family HELENOPORIDAE fam. nov.

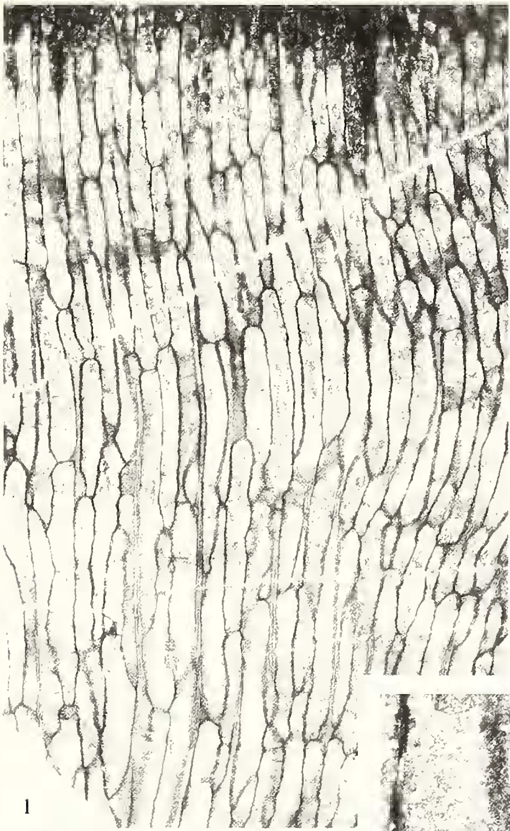
*Type genus*. *Helenopora* gen. nov.

*Derivation of name*. Family name is derived from the genus *Helenopora*.

*Diagnosis*. Colonies subspheroidal or hemispheroidal. Parallel type of colony with zooecia arranged more or less parallel to one another and rising from the basal epitheca at about right angles. Maculae present. Zooecia large and tubular with diaphragms thin, rare to common. Zooecial walls very thin and gently crenulate. Microcrystallites in the walls aligned in indistinct laminate pattern. Steep wall laminae almost parallel the zooecial tube. Mesozooecia present but not common. Acanthoforms common, large, and at zooecial wall junctions. Acanthoform wall structure

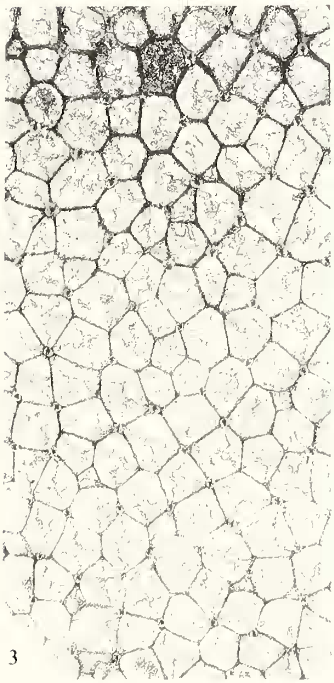
EXPLANATION OF PLATE 47

Figs. 1–4. *Helenopora duncanae* gen. et sp. nov. Upper Mississippian. Holotype. USNM 165087. Moffat Trail Limestone Member, Amsden Formation, Moffat Trail, Salt River Range, Wyoming (USGS 22987-PC). 1, longitudinal section shows budding pattern of expanding colony, × 10. 2 and 4, longitudinal sections show thin granular walls, some of which are penetrated by acanthoforms, × 20 and × 50, respectively. 3, deep tangential section shows polygonal zooecia and acanthoforms at junctions of zooecial walls, × 20.



1

2



3

4

ROSS, *Helenopora*

distinctly laminate. Steeply sloping laminae of acanthoforms curve gently convexly in the central region. Zooecia bud from the floor of diaphragms.

*Remarks.* Characters distinctive of Helenoporidae are: thin, indistinctly laminate walls; large zooecia; large acanthoforms with distinctly laminate walls; unique zooecial budding pattern. These characters distinguish the family from all other trepostome families.

The term acanthoform is used in preference to acanthostyle to identify a rod-like structure with laminate walls and an axial region. The term carries no inference about its function and no inference as to whether the structure was a solid rod or a hollow tube.

*Helenopora* is the only genus presently known in this family.

*Occurrence.* Late Mississippian of the western interior of the US (Utah, Idaho, Wyoming, and Montana) (text-fig. 1A, west of region 1 near western border of Utah, regions 2–9). Text-fig. 1B gives the stratigraphic units for the specific regions. Specific distribution data are given in the appendix.

## Genus HELENOPORA gen. nov.

*Type species. Helenopora duncanae* sp. nov.

*Derivation of name.* The genus is named in honour of the late Helen M. Duncan who had an extensive and remarkable knowledge of bryozoans.

*Diagnosis.* See family diagnosis. Additional features are: larger than normal zooecia in clusters that form indistinct maculae. Mesozooecia small, rare, and with polygonal outlines.

*Remarks.* The distinctive budding pattern, colony form, large zooecial tubes with diaphragms, and large acanthoforms characterize this genus which is dissimilar to other trepostome genera. For example, *Chondraulus* Duncan has a thin laminate colony form, a granular microstructure in its zooecial walls, numerous acanthoforms, and no mesozooecia. *H. duncanae* sp. nov. is the only species presently known in the genus.

Girty (in Mansfield 1927, pp. 68, 69) in a palaeontological report on fossil collections from Idaho referred to a bryozoan genus *Anomalopora* in species lists, but this genus and the species were never described or figured. In unpublished reports, specimens of *Helenopora* were informally referred to *Anomalopora* by several geologists including Helen Duncan. The sample USGS 101A-PC, collected by Girty from Idaho, contains small, hemispheroidal colonies of *Helenopora*.

### *Helenopora duncanae* sp. nov.

Plates 46–49

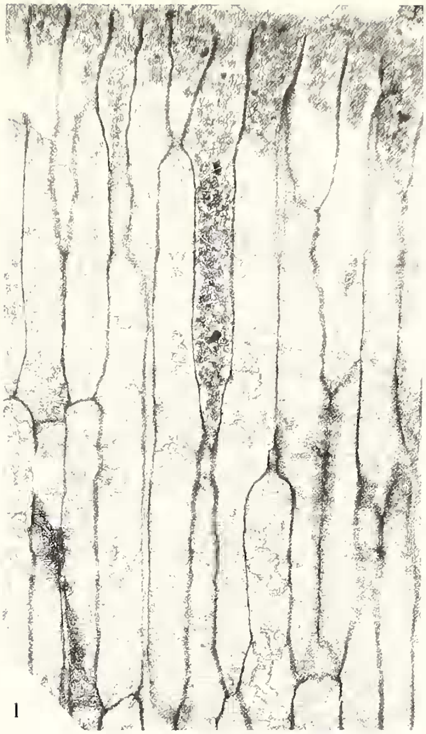
*Type material.* Holotype, USNM 165807, locality (20). Paratypes: USNM 419790, locality (21); USNM 419791, locality (18); USNM 419792, locality (19); USNM 419785, 419793, locality (13); USNM 419794, locality (11); USNM 419795, locality (2); USNM 419796, locality (22). Detailed stratigraphic and locality data are listed in the Appendix.

*Derivation of species name.* Dedicated to the late Helen Duncan.

---

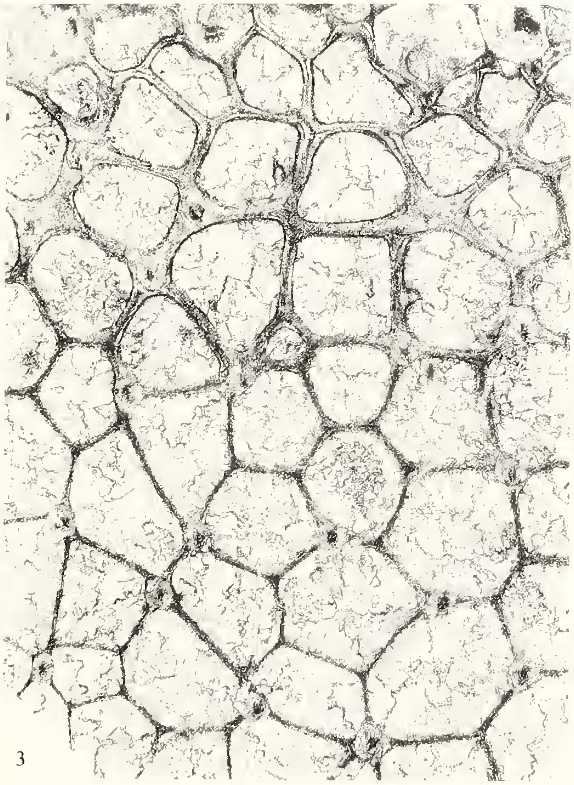
EXPLANATION OF PLATE 48

Figs. 1–4. *Helenopora duncanae* gen. et sp. nov. Upper Mississippian. Holotype. USNM 165087. Moffat Trail Limestone Member, Amsden Formation, Moffat Trail, Salt River Range, Wyoming (USGS 22987-PC). 1 and 2, longitudinal sections show budding pattern of zooecia, × 20 and × 50, respectively. 3 and 4, tangential sections show variation in wall thickness and acanthoform diameter, × 50.

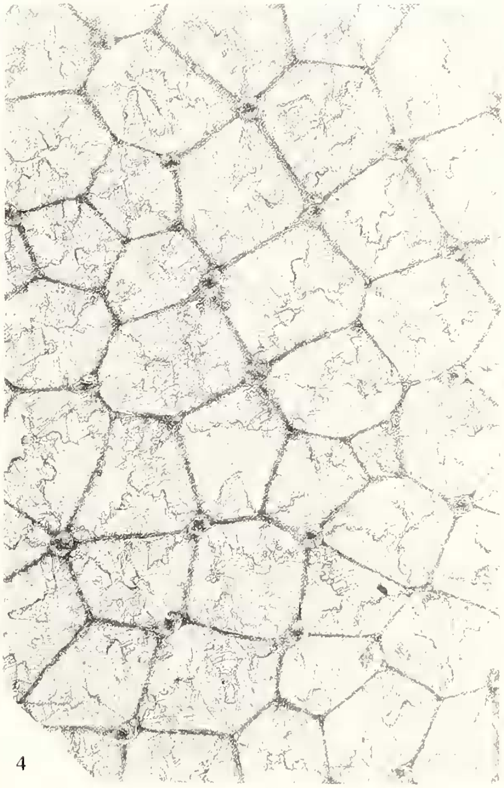


1

2



3



4

ROSS, *Helenopora*

*Description.* Subspheroidal or hemispheroidal colonies (Pl. 46, figs. 1 and 2), sometimes laminate, ranging in diameter at the base of the colony from about 3 cm to about 9 cm and in height from 2 cm to 27 cm. Width across the distal part of a large colony may reach more than 25 cm. The colonies vary in appearance from large oversize globular buttons, sometimes with arched convex bases, to large spheroidal or hemispheroidal boulder-size masses.

Polygonal to subpolygonal zooecial openings range in size across a colony surface and in different colonies from (0·09–0·46) × (0·05–0·38) mm. In maculae, zooecial openings range from (0·28–0·34) × (0·32–0·46) mm. Number of zooecial openings per square mm ranges from ten to fifteen. In tangential sections (Pl. 48, figs. 3 and 4), the narrow, indistinctly laminate zooecial walls generally are 0.008–0·026 mm in thickness, but they may reach 0·079–0·092 mm, particularly in maculae. The wider walls commonly enclose an acanthoform. In maculae, zooecial wall thickness averages 0·025 mm. Acanthoforms, located at the junctions of zooecial walls, have concentric laminate walls and clear axial regions. Acanthoform diameter is 0·05–0·09 mm. In maculae, the acanthoform diameter is generally 0·07–0·09 mm, however, there is a range from 0·05 to 0·09 mm.

In longitudinal sections (Pl. 4, figs. 1, 2, 4), thin, gently crenulate zooecial walls have steep wall laminae. Acanthoforms, where present, fill the zooecial walls and have steep sloping laminae in their walls that curve gently convexly in the central region. Zooecial tubes show a distinctive budding pattern with a new zooecial tube budding from the floor of a diaphragm (Pl. 47, figs. 1 and 2; Pl. 48, figs. 1 and 2; Pl. 49, fig. 2). Diaphragms are thin, flat, and generally widely spaced. In some colonies from locality USGS 20253, diaphragms are more numerous indicating a variation in the abundance of diaphragms in different colonies. Mesozooecia, small polygonal tubes, are rare and scattered among the zooecia. There is no increase in numbers of mesozooecia in the poorly defined maculae which are clusters of larger than normal zooecia.

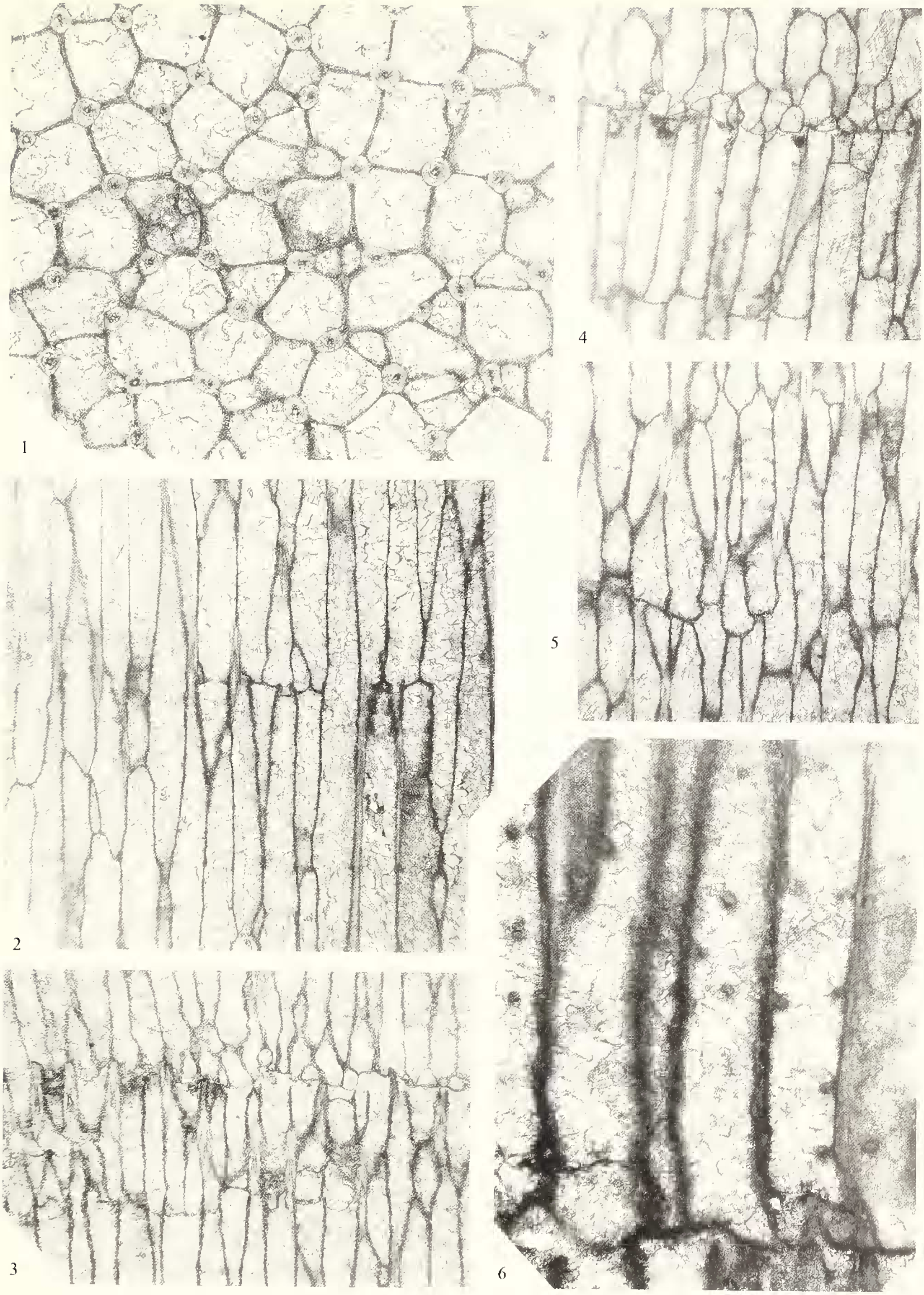
*Discussion.* In some colonies, such as those in samples USNM 419785 (loc. USGS 101A-PC) (Pl. 46, figs. 3–5; Pl. 49, fig. 1), there appear to be distal structures in a few of the zooecia. The distal structures have an inner circular area and an outer area with radiating lines (between four to eight), like spokes of a wheel, which join the inner area to the zooecial walls. The inner area shows concentric features in some sections (Pl. 49, fig. 1). Conti and Serpagli (1987) described a 'cap-like apparatus' in some zooecia of *Hallopora elegantula* from the Upper Ordovician of Sardinia. The cap-like apparatus had two parts, an inner raised part which had six to eight porous radial ridges and a slightly depressed outer part of six to eight porous radial ridges. The ridges were more or less aligned from the inner to the outer parts. The structures in *Helenopora duncanae* are similar, but not identical to those in *Hallopora elegantula.* Some colonies from localities USGS 15291 and 20255 in Utah and USNM 419786 (loc. USGS 18521-PC) (Pl. 49, fig. 5) and USNM 419788 (loc. USGS 18167) (Pl. 49, fig. 6) in Idaho show short arrow-shaped spines along the sides of the zooecial walls.

This species recolonized surfaces of colonies by means of overgrowths by parallel colony growth (Männil 1961, fig. 1*a*) (Pl. 49, figs. 3 and 4), many of which would then extend as laminae further increasing the size of the colony. Seasonal growth may be present in the colonies, but it is not marked by regular thickening across a colony or by alignment of diaphragms across a colony.

---

EXPLANATION OF PLATE 49

Figs. 1–6. *Helenopora duncanae* gen. et sp. nov. Upper Mississippian. 1, tangential section shows distal structure within zooecium, × 50. USNM 419785. Aspen Range Formation, Caribou County, Idaho (USGS 101-A-PC). 2 and 5, longitudinal sections. 2, shows budding from floor of zooecium; 5, shows spines projecting from zooecial walls, USNM 419786, × 20, Aspen Range Formation, Wells Canyon, Idaho (USGS 18521). 3 and 4, longitudinal sections show overgrowths, USNM 419787 and USNM 419788, respectively, × 20. 3, Doughnut Formation, near Mount Raymond, Utah (USGS 14496-PC); 4, probably in Surrett Canyon Formation, near Arco, Butte County, Idaho (USGS 18167-PC). 6, longitudinal section cuts tips of spines which appear as dark dots, USNM 419788, × 50, see stratigraphic and locality data for 4 above.




ROSS, *Helenopora*

## Family ASTRALOCHOMIDAE fam. nov.

*Type genus. Astralochoma* gen. nov.

*Derivation of name.* Family name is derived from the star-studded arrangement of maculae on the colony surface.

*Diagnosis.* Colonies subspheroidal or hemispheroidal. Parallel type of colony with zooecia arranged more or less parallel to one another and rising from the basal epitheca at about right angles. Maculae distinct with one or more clusters of mesozooecia in a central region and enclosed by very large zooecia. Zooecia large and tubular with diaphragms. Zooecial walls thin and granular. Microcrystallites in the walls form no distinct pattern. Mesozooecia numerous, partly surround zooecia but do not isolate zooecia on all sides. Acanthoforms numerous and small and at junctions of zooecia and mesozooecial walls. Acanthoform wall structure thin, indistinct. Zooecia bud by fission and bud from distal wall of preceding zooecium.

*Remarks.* Characters distinctive of Astralochomidae are: thin, indistinct granular walls; large zooecia; numerous small acanthoforms; maculae, large and distinct; zooecial budding by fission of preceding zooecium. These characters distinguish the family from all other trepostome families.

*Astralochoma* is the only genus presently known in this family.

*Occurrence.* Late Mississippian in age; western interior of the US (Utah and Wyoming) (text-fig. 1A, regions 1, 2, 7 and west of region 1). Specific distribution data are given in the appendix.

## Genus ASTRALOCHOMA gen. nov.

*Type species. Astralochoma helenae* sp. nov.

*Derivation of name.* The generic name describes the star-like appearance of the maculae.

*Diagnosis.* See family diagnosis. Additional features are: diaphragms sparse in zooecial tubes. Zooecial walls gently crenulate. Mesozooecia small. Acanthoforms indistinct.

*Remarks.* The distinctive maculae, colony form, large zooecial tubes with granular walls, numerous small acanthoforms, and zooecial budding by fission characterize this genus which is dissimilar to other trepostome genera.

### *Astralochoma helenae* sp. nov.

Plates 50 and 51

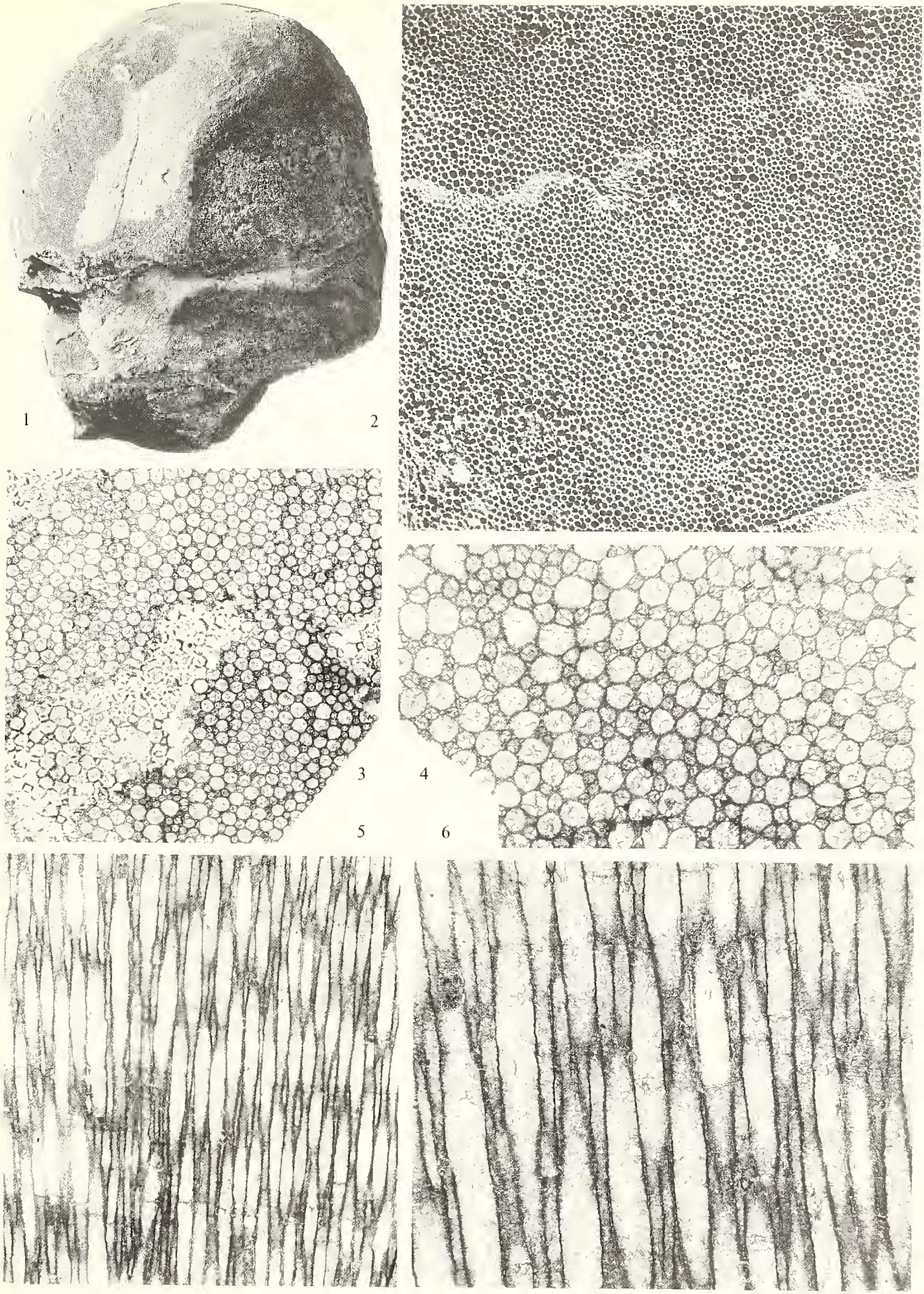
*Type material.* Holotype, USNM 165086, locality (17). Paratypes: USNM 419797, locality (16); USNM 419798, 419799, locality (1). Detailed stratigraphic and locality data are listed in the Appendix.

*Description.* Subspheroidal or hemispheroidal colonies (pl. 50, fig. 1), sometimes laminate, ranging in diameter at the base of the colony from about 4 cm to 10 cm and in height from 2 to 14 cm. Maculae (Pl. 50, fig. 2) vary is size from circular areas 3·8 mm² to elliptical areas which are larger 10·6 mm² (axes 1·4 × 2·4 mm). The colonies generally appear as large globular buttons or more massive boulder-like concretions. Rounded

---

EXPLANATION OF PLATE 50

Figs 1–6. *Astralochoma helenae* gen. et sp. nov. Upper Mississippian. 1 and 2, external views of hemispheroidal colony and colony surface with zooecial openings, USNM 419789, × 1 and × 5, respectively. Great Blue Limestone, near Dry Canyon, Oquirrh Mountains, Utah (USGS 21146-PC). 3 and 4, tangential sections show zooecia, mesozooecia, and acanthoforms, holotype, USNM 165086, Moffat Trail Limestone Member, Amsden Formation, Covey Cutoff Trail, Salt River Range, Wyoming (USGS 6965-PC). 5 and 6, longitudinal sections show budding pattern, holotype, USNM 165086, × 10 and × 20 respectively, locality data same as for 3 and 4.




ROSS, *Astralochoma*

subpolygonal zooecial openings (Pl. 50, figs. 3 and 4; Pl. 51, fig. 1) range in size from 0·17 to 0·23 mm. In maculae, zooecial openings (Pl. 51, figs 3 and 4) are larger than normal and range in size from 0·28 to 0·36 mm. The number of zooecia per square mm is fourteen to twenty and in maculae the number of zooecia per square mm. is nine to twelve.

In tangential section, narrow granular walls, 0·015–0·025 mm thick, have small acanthoforms at the junctions of zooecia and mesozooecia (Pl. 50, figs. 1 and 2). The wall thickness in maculae is 0·021–0·029 mm. Acanthoforms lie at each corner shared with adjacent zooecia or mesozooecia so that there are between four to six acanthoforms per zooecium. The acanthoforms are 0·017–0·025 mm in diameter and are smaller in the maculae, 0·017 or slightly smaller. The mesozooecia are triangular to rhomboidal and measure 0·06–0·10 mm. In maculae, the mesozooecia approximate to squares and measure 0·100–0·125 mm.

In longitudinal sections (Pl. 50, figs. 5 and 6; Pl. 51, fig. 2) thin, granular, and gently crenulate walls enclose the zooecia. Thin, flat diaphragms periodically cross the zooecia. Acanthoforms are not particularly distinctive unless the section passes through a junction between three walls of zooecia and mesozooecia.

*Remarks.* Although the colony form is very similar to that of *H. duncanae* sp. nov., this species has very different characters of the zooecial walls, zooecial budding, structure of the maculae, and the structure and distribution of acanthoforms and mesozooecia.

*Acknowledgements.* I thank Drs J. T. Dutro, Jr., Mackenzie Gordon, Jr., O. Karklins, W. J. Sando, and Mr H. Saunders, US Geological Survey, for their considerable assistance with information about the location of specimens and their stratigraphic occurrence. Dr C. A. Ross, Chevron USA, greatly assisted in the preparation of illustrations and in discussions on the palaeogeography. Support for publication from the Bureau for Faculty Research, Western Washington University, is gratefully acknowledged.

## REFERENCES

ASTROVA, G. G. 1978. The historical development, systematics and phylogeny of the Bryozoa. *Trudi Paleont. Inst. Akad. Nauk SSSR*, **169**, 240 pp. [In Russian.]

CONTI, S. and SERPAGLI, E. 1987. Functional morphology of the cap-like apparatus in autozooids of a Palaeozoic trepostome bryozoan. *Lethaia*, **20**, 1–20.

LAGESON, D. R., MAUGHAN, E. K. and SANDO, W. J. 1979. The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States—Wyoming. *Prof. Pap. US geol. Surv.* **1110-U**, 38 pp.

MÄNNIL, R. M. 1961. On the morphology of the hemispheric zoaria of the Trepostomata (Bryozoa). *Trudi Inst. Geol. Akad. Nauk Est. SSR*, **6**, 113–140. [In Russian.]

MANSFIELD, G. R. 1927. Geography, geology, and mineral resources of part of southeastern Idaho with descriptions of Carboniferous and Triassic fossils by G. H. Girty. *Prof. Pap. US geol. Surv.* **152**, 453 pp.

SANDO, W. J. 1975. Coelenterata of the Amsden Formation (Mississippian and Pennsylvanian) of Wyoming. *Ibid.* **848-C**, 31 pp.

—— 1976. Mississippian history of the northern Rocky Mountains region. *J. Res. US geol. Surv.* **4**, 317–338.

—— and BAMBER, E. W. 1979. Coral zonation of the Mississippian System of western North America. *9th Internat. Cong. Carb. Strat. Geol., Urbana, Illinois, 1979. Abstracts of Papers*, p. 191.

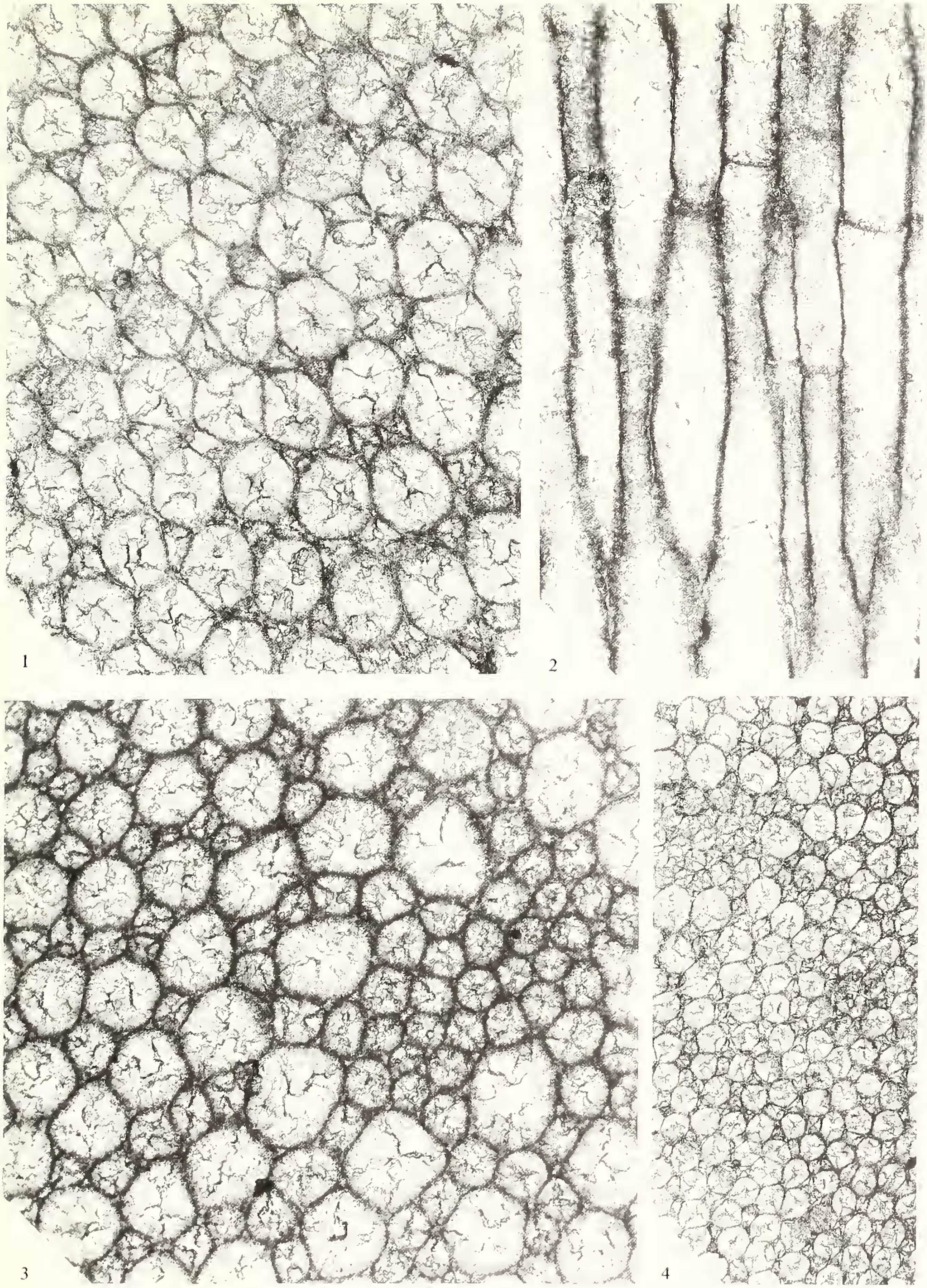
—— —— 1984. Coral zonation of the Mississippian System of western North America. *In* SUTHERLAND, P. K. and MANGER, W. L. (eds.). *Neuvième Congrès International de Stratigraphie et de Géologie du Carbonifère, Compte Rendu* **2**, *Biostratigraphy*, 289–300. Southern Illinois University Press, Carbondale and Edwardsville.

—— —— 1985. Coral zonation of the Mississippian System in the western interior province of North America. *Prof. Pap. US geol. Surv.* **1334**, 61 pp.

---

### EXPLANATION OF PLATE 51

Figs. 1–4. *Astralochoma helenae* gen. et sp. nov. Upper Mississippian. Holotype. USNM 165086. Moffat Trail Limestone Member, Amsden Formation, Covey Cutoff Trail, Salt River Range, Wyoming (USGS 6965-PC). 1, 3, 4, tangential sections. 1, area between maculae with regular, subrounded-polygonal zooecia, ×50; 3 and 4, areas with maculae (aggregations of mesozooecia) and enlarged zooecia adjacent to maculae, ×50 and ×20, respectively. 2, longitudinal section shows thin granular and gently undulate walls and zooecia budding by fission, ×50.




ROSS, *Astralochoma*

SANDO, W. J., GORDON, M., JR. and DUTRO, J. T., JR. 1975. Stratigraphy and geologic history of the Amsden Formation (Mississippian and Pennsylvanian) of Wyoming. *Prof. Pap. US geol. Surv.* **848-A,** 83 pp.

—— MAMET, B. L. and DUTRO, J. T. JR., 1969. Carboniferous megafaunal zonation in the northern Cordillera of the United States. Ibid. **613-E,** 29 pp.

—— SANDBERG, C. A. and GUTSCHICK, R. C. 1981. Stratigraphic and economic significance of Mississippian sequence at North Georgetown Canyon, Idaho. *Bull. Am. Ass. petrol. Geol.* **65,** 1433–1443.

SKIPP, B., SANDO, W. J. and HALL, W. E. 1979. The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States—Idaho. *Prof. Pap. US geol. Surv.* **1110-AA,** 42 pp.

SMITH, D. L. and GILMOUR, E. H. 1979. The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States—Montana. Ibid. **1110-X,** 32 pp.

TOOKER, E. W. and ROBERTS, R. J. 1963. Comparison of Oquirrh Formation sections in the northern and central Oquirrh Mountains, Utah. Ibid. **450-E,** E32–E36.

—— —— 1970. Upper Paleozoic rocks in the Oquirrh Mountains and Bingham Mining District, Utah, with a section on biostratigraphy and correlation by Gordon, M., Jr. and H. M. Duncan. Ibid. **629-A,** 76 pp.

WELSH, J. E. and BISSELL, H. J. 1979. The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States—Utah. Ibid. **1110-Y,** 35 pp.

JUNE R. P. ROSS

Department of Biology
Western Washington University
Bellingham, WA 98225, USA

Typescript received 31 March 1987
Revised typescript 1 December 1987

## APPENDIX

### Locality data and occurrence of species

The trepostome-bearing samples are from regions (numbered 1 to 9 on text-fig. 1) which during the late Mississippian were located on various parts of the western shelf and shelf margin of the North American craton. In these regions, different stratigraphic nomenclatures are applied to upper Mississippian strata and emphasize differences in their depositional histories and sedimentary environments (Text-fig. 1).

UTAH. Region 1. Locality (1). USGS collection 21146-PC. Stockton 15-minute quadrangle, Tooele County. Near centre N$\frac{1}{2}$ sec. 21, T. 5 S., R. 4 W. in fault block in Great Blue Limestone about 61 m (200 ft.) west of Lakes Killarney fault, 15–30 m (50–100 ft.) in elevation below top of ridge and on its south slope, and $\frac{1}{4}$-mile north-west of mouth of Dry Canyon. Upper part of Great Blue Limestone. Collected by M. Gordon, Jr. and E. W. Tooker in 1962. *A. helenae.*

West of region 1. Locality (2). USGS collection 20547-PC. Confusion Range, near the western border of Utah. Granite Mountain, E$\frac{1}{2}$ S$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 18, T. 14 S., R. 16 W. From 7 m (30 ft.) of beds with large *Caninia* specimens. On the western edge of the Mississippian Great Blue carbonate shelf where it became predominantly clastic and about at the same latitude as the previous collection. Chainman Shale. Collected by M. Gordon, Jr., H. Duncan, R. A. Lewandowski, and A. Rieke in 1961. *Helenopora duncanae* and *A. helenae.*

Region 2. Locality (3). USGS collection 16330-PC. Farnsworth Peak 7$\frac{1}{2}$-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section, Oquirrh Mountains (Tooker and Roberts 1970). On ridge south of Green Ravine below tramway tower, approximately on 5400-ft. contour in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 6, T. 2 S., R. 3 W. Green Ravine Formation. Collected in limestone, 62 m (203 ft.) above base of unit 11 of type section, 327 m (1074 ft.) above base of formation. Collected by E. W. Tooker and R. J. Roberts in 1956. *A. helenae.*

Locality (4). USGS collection 17143-PC. Farnsworth Peak 7$\frac{1}{2}$-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section, Oquirrh Mountains (Tooker and Roberts 1970). Below 5400-foot contour, a few feet up north slope from bottom of Green Ravine, about one-eighth mile east of hill 5244′ in the SE$\frac{1}{4}$ SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 6, T. 2 S., R. 3 W. Green Ravine Formation. Collected from interbedded limestone and argillaceous limestone, 78·6 m (258 ft.) from base of unit 11 of type section, 344 m (1129 ft.) above the base of the formation. Collected by M. Gordon, Jr. and R. J. Roberts in 1957. *H. duncanae.*

Locality (5). USGS collection 20253-PC. Farnsworth Peak 7$\frac{1}{2}$-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section, north end of Oquirrh Mountains (Tooker and Roberts 1970). North slope of Green Ravine at 5320-foot contour in SW$\frac{1}{4}$ SE$\frac{1}{4}$ NW$\frac{1}{2}$ sec. 6, T. 2 S., R. 3 W. Green Ravine

Formation. Collected from limestone about 49 m (160 ft.) above base of unit 11 of type section, 314 m (1031 ft.) above base of formation. Collected by H. Duncan, E. W. Tooker, and R. A. Lewandowski in 1961. *H. duncanae*.

Locality (6). USGS collection 20255-PC. Farnsworth Peak 7½-minute quadrangle, Tooele County. Green Ravine–Rogers canyon measured section, Oquirrh Mountains (Tooker and Roberts 1970). North of Green Ravine near middle of west line of SE¼ NW¼ sec. 6, T. 2 S., R. 3 W., at 5400-foot contour. Green Ravine Formation. Collected from interbedded fissile limestone and argillaceous limestone, 26·5 m (87 ft.) above base of unit 12 of type section, 393 m (1289 ft.) above base of formation. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski in 1961. *H. duncanae*.

Locality (7). USGS collection 20256-PC. Farnsworth Peak 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section, Oquirrh Mountains (Tooker and Roberts 1970). On ridge north of Green Ravine in the NE¼ SW¼ NW¼ sec. 6, T. 2 S., R. 3 W., at 5320-foot contour. Green Ravine Formation. Collected from argillaceous limestone, 91 m (298 ft.) above base of unit 11 of type section, 356 m (1169 ft.) above base of formation. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski in 1961. *H. duncanae*.

Locality (8). USGS collection 20257-PC and USGS collection 21131-PC. Farnsworth Peak 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section, Oquirrh Mountains (Tooker and Roberts 1970). On ridge north of Green Ravine, same as locality (4). Green Ravine Formation. Collected by H. M. Duncan, M. Gordon, Jr., E. W. Tooker, and R. A. Lewandowski in 1961. *H. duncanae*.

Locality (9). USGS collection 21130-PC. Farnsworth Peak 7½-minute quadrangle, Tooele County. Green Ravine–Rogers Canyon measured section, Oquirrh Mountains (Tooker and Roberts 1970). Summit of ridge north of Green Ravine, about one-eighth mile east of knoll 5244′. Same general locality as USGS collection 20257-PC. Green Ravine Formation. Collected from 2·4 m (8 ft.) of dark grey shaly limestone immediately underlying base of limestone bed, 60 m (198 ft.) above base of unit 11 of type section, 326 m (1069 ft.) above base of formation. Collected by H. M. Duncan, E. W. Tooker, and R. A. Lewandowski in 1961. *H. duncanae*.

Region 3. Locality (10). USGS collection 14496–PC. Morgan 15-minute quadrangle. About 2 miles east-north-east of Morgan, near Mount Raymond, Wasatch Mountains. North slope of east trending ridge which is the next ridge south of the one on which the type Morgan section was measured (Tooker and Roberts 1970). NW¼ sec. 29, T. 4 N., R. 3 E. Upper part of Doughnut Formation. Collected by M. Gordon, Jr., E. Yochelson, and M. Crittenden in 1953. *H. duncanae*.

Region 4. Locality (11). USGS collection 15177-PC. Mount Pisgah 7½-minute quadrangle, Cache County. T. 10 N., R. 1 W., SW¼. Limestone 23 m (75 ft.) stratigraphically below cairn at top of Dry Lake section hill. Northern facies of the Great Blue Limestone where it starts to grade laterally into the inner shelf Doughnut Formation. Great Blue Limestone. Collected by M. Gordon, Jr., G. Sohn, and P. Knopf in 1954. *H. duncanae*.

Locality (12). USGS collection 15291-PC. Mount Pigsah 7½-minute quadrangle, Cache County. T. 10 N., R. 1 W., SW¼. Bryozoan from float 9 m (30 ft.) stratigraphically below station 18 in Dry Lake section. Great Blue Limestone. In its northern facies where it starts to grade laterally into the inner shelf Doughnut Formation. Collected by M. Gordon, Jr. *H. duncanae*.

Idaho. Region 5. Locality (13). USGS collection 101A-PC. Crow Creek 15-minute quadrangle, Caribou County. Sec. 10, T. 10 S., R. 45 E. Shelf margin Aspen Range Formation. Probably from thick-bedded limestone (Girty in Mansfield 1927). Collected by G. H. Girty in 1911. *H. duncanae*.

Locality (14). USGS collection 18521-PC. Crow Creek 15-minute quadrangle, Caribou County. Wells Canyon, north side along tributary creek about in NE sec. 9, T. 10 S., R. 45 E. and above stream to west. About 15 to 20 m (50 to 60 ft.) east of easterly point in first switchback of road and about 6 m (20 ft.) below road. Shelf margin Aspen Range Formation. Probably from thick-bedded limestone. Collected by W. D. Keller and J. S. Williams in 1935. *H. duncanae*.

Region 6. Locality (15). USGS collection 18167-PC. Near Arco, Butte County, Idaho. North-east and uphill about one-half mile on Main Street. The road went north-east to a small pass and the outcrops were on the south-west side of road. At 6 m (20 ft.) above lowest outcrop, there was a bed with many '*Chaetetes*'. Outer edge of the thick carbonate wedge which formed on the Mississippian cratonic shelf margin. Collected by J. S. Williams in 1953. This collection is probably from the Surrett Canyon Formation. *H. duncanae*.

Wyoming. Region 7. The Mississippian shallow water, mixed clastic-carbonate shelf area of south-western Wyoming forms region 7 and includes five collections from the Moffat Trail Limestone Member of upper part of the Amsden Formation, Salt River Range, Lincoln County, Wyoming (Sando *et al.* 1975):

Locality (16). USGS collection 6957-PC. Bear Creek, Salt River Range. NE¼ SW¼ SW¼ sec. 27, T. 33 N., R. 117 W. Collected by J. S. Williams in 1931. *A. helenae*.

Locality (17). USGS collection 6965A-PC. Covey Cutoff Trail, Salt River Range. NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 27, T. 34 N., R. 117 W. Limestone 84 m (277 ft.) above base of Amsden Formation. Collected by J. S. Williams in 1931. *A. helenae*.

Locality (18). USGS collection 17907-PC. Haystack Peak section, Salt River Range. Centre sec. 19, T. 34 N., R. 117 W. 61–64 m (199–209 ft.) above base of Amsden Formation. Collected by W. J. Sando and J. T. Dutro, Jr. in 1958. *H. duncanae*.

Locality (19). USGS collection 22986-PC. Moffat Trail, Salt River Range. NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 3, T. 33 N., R. 117 W. Limestone 64 m (210 ft.) above base of Amsden Formation. Collected by J. T. Dutro, Jr. and Mario Suarez in 1966. *H. duncanae*.

Locality (20). USGS collection 22987-PC. Locality same as Locality (19) but 66 m (217 ft.) above base of Amsden Formation. *H. duncanae*.

Region 8. Locality (21). USGS collection 16209-PC. Hoback Canyon, Teton County, sec. 2, T. 38 N., R. 115 W. Float from limestone 23–28 m (76–91 ft.) above top of Darwin Member, Moffat Trail Limestone Member. Along the Mississippian edge of the western Wyoming shallow water, clastic-rich shelf where the Amsden Formation may be subdivided into several additional members. Collected by M. Gordon, Jr., and others in 1955. *H. duncanae*.

MONTANA. Region 9. Locality (22). USGS collection 17517-PC. Tostin 15-minute quadrangle, Broadwater County. Lombard section. SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 7, T. 4 N., R. 3 E. 73 m (240 ft.) above base of Big Snowy Formation. About 0·25 mile west of railroad station at the town of Lombard, Montana. In the late Mississippian, region 9 in south-central Montana contained a broad channel which marked the northern limit of the Wyoming shallow water shelf and which also served as a connection to the Williston evaporite basin to the east. Collected by J. T. Dutro, Jr. and W. J. Sando. *H. duncanae*.